Title

Climate Change and Water Resources in California: The Cost of Conservation versus Supply Augmentation for the East Bay Municipal Utility District

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Abstract:

This paper compares the cost per acre-foot to the East Bay Municipal Utility District (EBMUD) of conservation versus an increase in size of Pardee Reservoir. The paper analyzes two components of the EBMUD's 2009 Water Plan for meeting demands in 2040: promoting more rigorous conservation methods for its customers, and increasing the size of Pardee Reservoir by the construction of a new dam ¾ mile downstream from the existing location. Additionally, the paper analyzes five documents published by EMBUD over the last 12 years, for discussion of reservoir expansion, conservation targets, and climate change.

Introduction:

Climate change is projected to result in increasing water scarcity scenarios in California, and similar Mediterranean climates. California's largest natural reservoir, snow pack, is projected to decrease by 30% by conservative estimates, and up to 80% by higher warming scenarios by 2070-2099 (Kahrl and Roland-Holst 2008). The loss of snow pack will lead to increased water flows in winter, when demand is low, and decreased flow in the spring and summer when demand is at its highest. Moreover, population in California is projected to increase by 37 percent between 2000 and 2030 (US Census, 2005). To meet the growing water demand due to population increases, with changing supplies due to climate change, water agencies across the state are developing water plans incorporating a range of supply and demand-side options to address the potential future short-fall of available water.

This paper examines and critiques two components of the East Bay Municipal Utility District's (EBMUD) recent Water Supply and Management Plan for 2009-2040: aggressive water conservation and the enlargement of Pardee Reservoir (EBMUD 2009). In addition, I examine five water planning documents published by EBMUD, analyzing three factors: 1. Climate change as a factor for increasing supply, 2. Conservation targets, and 3. Expansion of Pardee Reservoir as an additional supply option.

The paper begins with a discussion of the background of EBMUD's most recent Management Plan, and two specific components of its Preferred Portfolio: increased conservation and supply augmentation through the expansion of Pardee Reservoir. The Methods discussion provides an overview of documents reviewed, and the Results section presents a summary table of documents reviewed, and focuses on cost estimates produced by EBMUD and its consultants associated with its preferred conservation program and the enlargement of Pardee Dam. The Discussion section provides an interpretation of the results, points out concerns in the findings, and raises issues surrounding the debate of reservoir expansion and aggressive conservation.

Background

The East Bay Municipal Utility District (EBMUD) serves a population of 1.3 million people in Contra Costa and Alameda Counties, and its current water demand is 230 million gallons per day (MGD). In the WSMP 2040, EBMUD assumes it will see a similar rate of growth as projected for the state by the US census of 37 percent between now and 2040, resulting in an expected population of 1.78 million. Water demand in 2040 is estimated to be 280 MGD, resulting in an additional 50 MGD to current water demand (EBMUD 2009).

Options for meeting water demand include conservation, pricing, rationing, and supply augmentation. Supply augmentation can include increased water storage through reservoirs and groundwater, desalination, water transfers, rainwater harvesting, as well as water recycling. Conservation efforts include water surveys to increase understanding of how water is used to better assist reduction, rebates for more efficient washers, dishwashers, and toilets; incentives for irrigation upgrades such as low volume sprinkler heads, rain sensors, and check valves; smart meters that allow for hourly consumption data, incentives for the installation of artificial turf for sports fields and homes, and require new developments to install high efficiency toilets, showerheads, dishwashers, and washing machines (Maddaus 2009).

In February 2009, EBMUD released its water management proposal for meeting water demands through 2040. This report specifically aims to provide a strategy for meeting demand in a three-year consecutive drought scenario. In this document EBMUD presented its Preferred Portfolio, made up of both supply and demand side approaches, as well as five alternative portfolios (EBMUD 2009). Each of the alternative portfolios was identified by a particular theme, based on the emphasized component. These five themes were: Groundwater/Conjunctive Use and Water Transfers, Regional Partnerships (which includes regional desalinization, groundwater, and enlarging Lower Bear Reservoir), Local System Reliance (new storage, rationing, and developing Buckhorn Canyon Reservoir), Lower Carbon Footprint (expansion of Pardee Reservoir, rationing, recycled water and groundwater) and Recycled Water and Water Transfers (emphasis on water transfers). It should be mentioned that in all five of the Alternative Portfolios, conservation at the rate of 37 – 39 MGD was included as a component (EBMUD 2009). Among the recommendations in its Preferred Portfolio is the proposal to expand the Pardee Reservoir by raising the dam level an additional 33 feet and increasing the storage size to 360,000 acre feet (adding 172,000 acre feet to the current reservoir storage capacity). The surface area of the reservoir would be increased from 2,200 acres to 3,480 (EBMUD, 2009).

The proposal to expand Pardee Reservoir is not new, as is discussed later in this paper, however was deemphasized after EBMUD secured water through the Freeport Regional Water Project. Entitlement to additional water began in the early 1970s, when EBMUD "executed a contract with the US Bureau of Reclamation for delivery of Central Valley Project water from the American River" (EBMUD 2005). Legal challenges ensued, leading to a 1990 court decision that affirmed EBMUD's right to water from the American River. Subsequently, EBMUD and parties in Sacramento proposed an alternative, with water being diverted from the Sacramento River near the town of Freeport. This plan was ultimately approved in 2004 and allocated 100 MGD in dry years to EBMUD (EBMUD 2005).

Methods and Results

Methods:

I critically reviewed five documents produced and/or released[1] by EBMUD and firms hired by EMBUD: "Water Supply Management Program (WSMP) 2040"; "Conservation Program Evaluation" from 2009; "Urban Water Management Plan 2005 and 2000; and the "Pardee Reservoir Enlargement Project Preliminary Design Report" from 1997. EBMUD's "Water Supply Management Program (WSMP) 2020 was not available on EBMUD's website, or when requested over email. I relied on secondary sources (such as the Urban Water Management Plans, and the Pardee Design Report) to analyze conservation and supply-side components included in the WSMP 2020. Based on the recommendations made in EBMUD's WSMP 2040 report in its Preferred Portfolio, which includes rationing, recycled water, conservation, and supplemental supply, I looked at two specific recommendations: Increased conservation efforts and the enlargement of Pardee Dam. Using documents published by EBMUD throughout the last 12 years, I estimated the cost per acre-foot for each of these two methods, adjusting for inflation in order to compare in today's dollar values. For the Total Cost of Water Saved, through conservation, I calculated this number based on the definition provided by Maddaus of Customer Cost plus Utility Cost. This number differs for the costs presented by Maddaus, who estimate the total cost between 30 – 40 % higher than those presented in Table 3 (Maddaus 2009).

Results:

Document analysis

Tables 1 and 2 provide an overview of four of the five documents analyzed in this paper. These tables summarize information presented in the documents, with particular focus on climate change, conservation, and enlargement of Pardee Reservoir.

[1] Several documents were produced by consulting firms hired by EBMUD, and made available on EBMUD's website.

Table 1: Comparison of Urban Water Management Plan 2000 and 2005						
	Source of EBMUD Water		Population served	Population Projection for 2020 year	Mention of Climate Change	Mention of Enlarging Pardee
	% provided from Moukeleme basin	% from EBMUD lands runoff				
2000	95	5	1.3 million	1.42 million	No	Yes
2005	90	10	1.3 million	1.475 million	Yes	No

Table 2: Comparison of Water Supply Management Plan 2020 and 2040						
	Publication Year	Base year	Conservation Goal (MGD)	Mention of Pardee Expansion	Mention of Climate Change	Rationing Level
2020	1993	1985	35	Yes	--	25% max
2040	2009	2010	39	Yes	Yes	10%[2]

Conservation

Maddaus Water Management (MWM), an independent consulting firm, produced a memo for EBMUD in March 2009, which is published on EBMUD's website, titled "Conservation Program Evaluation-Summary of Data Inputs, Assumptions and Results" providing a technical analysis on conservation measures that "could be implemented by EBMUD to reduce future water demand," as well as estimate the costs and water saving of the measures (Maddaus 2009). MWM provided EBMUD with five scenarios, each with different combinations of the 53 conservation measures and programs analyzed by MWM. The 53 conservation measures can be divided into two categories: 1. Technology, such as high efficiency faucets, toilets, showerheads, washers, and dishwashers; and 2. Services, such as surveying and smart metering.

The five scenarios presented, ranging from Program A, business as usual with only the Plumbing Code, to Program E, greatest investment in conservation. The Plumbing Code refers to the Federal Energy Policy Act of 1992, which was amended in 2005, and requires new buildings to install fixtures that meet certain standards for water efficiency (Building Standards Commission). In addition,

[2] This rationing level is the goal of EBMUD in its "Preferred Portfolio," however is dependent on securing additional water supply during dry years.

this code regulates the replacement of fixtures in existing buildings to also meet standards for water efficiency. In California, two additional laws are included in the broader "Plumbing Code": landscape model ordinances, and toilet and urinal installation in new buildings must be 1.28 gallons/flush and .5 gallon/flush, respectively (Maddaus 2009). The five Programs, each involving a combination of the 53 conservation measures (with the exception of Program A), are evaluated using MWM's Least Cost Planning Demand Management Decision Support System model. MWM's model produces costs ranging from $150 and $15 per unit for the utility and customer, respectively, for measures such as home water-use surveys; to measures that cost $10,000 and $250,000 per unit for the utility and customer respectively, to implement artificial turf on sports fields. The results of costs and water savings for each of the Programs are presented in Table 3.

Table 3: Comparison of Long-Term Conservation Programs-Costs and Savings[3]

Conservation Program	2040 Water Savings w/code (MGD[4])	Present Value of Water Utility Costs ($ Millions)	Present Value of Customer Costs ($ Millions	Utility Cost of Water Saved ($/AF[5])	Customer Cost of Water Saved ($/AF)	**Total Cost of Water Saved ($/AF)[6]**
Program A (Plumbing Code)	19.4	NA	NA	NA	.4	**.4**
Program B	27.0	40	191	143	946	**1089**
Program C	35.3	266	352	480	897	**1377**
Program D	37.2	387	437	634	1021	**1655**
Program E	38.6	543	578	845	1239	**2084**

Present Value of Water Costs is discounted to 2010, as the base year, using an interest rate of 3%. Utility Costs include the cost to the utility for implanting the conservation measures. The Total Cost of Water Saved is the sum of the cost to utility and customer. These costs can include rebate programs,

[3] Adapted from Maddus, 2009.
[4] MGD refers to million gallons per day.
[5] AF refers to acre-foot.
[6] The Total Cost of Water Saved was calculated by myself, and does not reflect the Total Cost of Water Saved presented in the Maddus report. The Total Costs estimated by Maddaus, titled "Community Cost" ranged from 30 – 40 % higher then the numbers presented in this table. There was no explanation by Maddus for what accounted for this cost increase, and therefore, I have decided to use the definition provided by Maddaus to calculate the Total Cost above.

overhead, marketing, and obtaining and maintaining equipment. Similarly, customer costs are those costs incurred by the customer, and can include capital costs for purchasing new equipment, as well as maintenance costs (Maddaus 2009).

Pardee Dam enlargement

EBMUD has not yet released a technical report on the expansion of Pardee Reservoir, therefore the primary source of data is from the June 1998 "Pardee Reservoir Enlargement Project Preliminary Design Report." This report was compiled and submitted by the HCG Pardee Project Team, an independent group hired by EBMUD and comprised of consultants from HDR Engineering Inc., Christensen Associates Inc., GEI Consultants Inc., and several sub-consultants (HCG 1998).

The 1998 report proposes the same expansion as presented in the 2009 WSMP 2040 Preferred Portfolio, namely raising the reservoir by 33 feet, and increasing the capacity by 172,000 AF. To gain this additional storage, both EBMUD in its current plan, as well as HCG's recommendation from 1998, proposes replacing the present dam by a new dam ¾ mile downstream.

The project estimated cost of $261.5 million in 1997 dollars, is equivalent (adjusted for inflation) to $357 million in 2009 dollars; cost per acre foot of new storage would be $1520 per acre foot in 1997 dollars, or $2087 per acre foot in 2009 dollars (HCG 1998). Table 4 presents a breakdown of the estimated costs for the reservoir expansion.

The categories listed in Table 4 are identical to those provided in the 1998 report. "Dams" refers to the construction of the new Pardee Dam as well as saddle dams, two of which will be constructed along the northern perimeter of the reservoir, and two others on the divide between the Mokelumne River and Jackson Creek. Roads, bridges, recreation facilities, and the power plant will all be relocated to new sites as these are all located in the area of inundation (HCG 1998).

Table 4: Projected Cost Estimate for Enlarging Pardee Reservoir[7]		
Item	**Cost (1997 $, in millions)**	**Cost (2009 $, in millions)**
Land Purchase	3	4.11
Reservoir Clearing/ Recreation Facilities	4.1	5.62
Roads/Bridges	8.7	11.93
Dams	131.4	180.32
Intakes	11.8	16.19
Penstock	2.8	3.84
Hydro Powerhouse	16.9	23.19
Subtotal	178.6	245.2
Engineering & Administration	35.7	48.99
Other Mitigation	3.6	4.94
Contingency	43.6	59.83
Total	**261.5**	**358.9**
Cost of New Storage per Acre-Foot		
	1,520	2,087

Discussion

Conservation

The five programs presented in Table 3 as generated by Maddaus range in water savings from approximately 19 to 39 million gallons per day (MGD). As pointed out by Maddaus, these numbers do not included a projected 2 MGD in water savings from existing EMBUD programs. EBMUD has used Maddus' Program D as its conservation target within the agency's Preferred Portfolio. Program D includes 41 conservation measures, which were chosen by EMBUD to include in the Program, which will create approximate 37 MGD in water savings, plus an additional 2 MGD from existing programs, for a total goal of 39 MGD in water savings by 2040, or 75% of projected demands (EBMUD, 2009; Maddus, 2009). The costs associated with the savings, as presented by Maddus, are a cost to utilities of $634 per acre-foot (AF) and $1,021 per AF for customer, with the total of $1,655 per AF as the cost of water saved through conservation (Maddaus 2009). I

Maddaus' programs and cost estimate include service and technology options, leaving out conservation block pricing structure as a method for promoting higher rates of conservation. Pricing has

[7] Adapted from HCG, 1998

been blocked consistently by the Board of EBMUD, as it would significantly effect high water users, primarily residents of the east side of the hills (Gammon 2009).

Conservation block pricing structures can provide both an incentive to conserve, otherwise face a significantly higher price for water, while still allowing utilities to cover their operation costs. Conservation block pricing would additionally bring down the overall cost of conservation programs on a dollar per acre-foot level, as it would not cost the utility any additional capital costs for implementing a pricing program.

Pardee Reservoir enlargement

To expand Pardee Reservoir, today, is estimated to cost be $2,086 per AF (HCG, 1998). The HCG report, however, does not clearly account for additional costs of utility relocation, modification of the tunnel used to transport water to the aqueduct, and the possible increase in land value over the last 12 years.

Expanding Pardee Reservoir has been seen as an option by EBMUD for the last nearly 20 years. I analyzed three documents that proposed the expansion of Pardee Reservoir, and summarized why this option was ultimately excluded from EBMUD's agenda (with the exception of WSMP 2040, which is still exploring this option).

Table 3: Timeline of Pardee Expansion Proposals

Year	Publication	Dam height increase	Proposed as	Reason excluded
1993	WSMP 2020	53 feet	Was a component in one of the alternative programs proposed	Downgraded because of impact on the Electra whitewater reach
1996-97	Technical Report, HCG Pardee Project Team	33 feet	---	Investigations suspended due to progress in case with Freeport transfer
2009	WSMP 2040	33 feet	Component of "preferred portfolio"	Being explored alongside regional desalination. Only one the two will be adopted

Challenges to both conservation and reservoir expansion

Assuming that the estimated costs of conservation and reservoir expansion are accurate, costs of conserved water are close to the cost of reservoir expansion (a difference of $430 per AF). However this calculation does not capture the impacts and broader debate associated with each action.

Implementing conservation measures can entail some challenges. For example, rationing has been used by EBMUD for decreasing demand. While rationing provides a short-term solution to significantly reduce demand, it results in a decrease in revenue for the utility, and therefore does not allow for full cost- recovery[8].

Environmental impacts of dams are well known and documented, and include the loss of aquatic ecosystems, change of river flow, including sedimentation flow and transport; inundation of habitat for terrestrial species, to name just a few. Arguably, these impacts will be far less in the area of preexisting reservoirs than the inundation of a new site. Opponents to the expansion of Pardee Dam cite the loss of a section of the river known for its whitewater rapids, as well as the loss of more habitat (Gammon 2009). In addition, inundating more land will release methane and carbon dioxide, both greenhouse gases (GHGs), from the decomposition of plants. Fish habitat will further be altered, both in the zone of inundation, as well as downstream due to less water flow. Lastly, GHG emissions associated with concrete for the dam, trucks and construction equipment making daily trips for more than three years, as the project timeline of construction, will also have associated impacts on carbon releases.

Conclusion

Since 1993, conservation efforts have reduced demand by 22.5 MGD (EBMUD 2009). Aggressive conservation is seen as a primary strategy for meeting future demand, however in planning for consecutive years of drought, EBMUD does not believe its conservation goals alone can meet

[8] Cost-recovery, an important concept for the water sector to meet its fixed and variable costs, was incorporated to the European Union's Water Framework Directive (WFD) Article 5. Article 5 calls for an economic analysis of water use to help identify cost-effective means for meeting the broader objectives of the WFD (Defra, UK).

demand. EBMUD's conservation projection may, however, be an underestimate if conservation pricing is included as a strategy for promoting greater conservation while meetings its costs.

Water conservation versus supply augmentation is certainly not going without notice. As the cover article of the East Bay Express recently wrote, "East Bay MUD wants to build a dam and ruin a scenic stretch of the Mokelumne River because it is not willing to make its suburban customers conserve water" (Gammon 2009). The recent three years of drought, continued population growth in California broadly, and the Bay Area specifically; and an overall greater awareness of climate change and its impacts on water in California, will certainly keep water demand and supply a topic for debate among water agencies and policymakers.

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